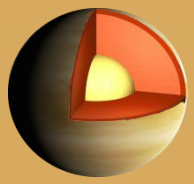

Venus Aerial Platforms Study

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June 11, 2018

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Topics

- Venus Aerial Platforms Study Overview
- Motivation
- Types of Aerial Platforms Considered
- Trade Study
- Trajectory Models
- Venus Entry Option Space
- Venus Aerial Platforms – Design Sweet Spot
- Technology Needs
- Summary

Venus Aerial Platforms Study Overview

- NASA Planetary Science Division has formed a study team to refine the preliminary roadmap for aerial platforms and develop a technology plan

- Two face-to-face study meetings were held in 2017 covering the science implementation concept and technical maturity
  - Scientific objectives and aerial platform options space (June 2017)
  - Technical feasibility and technology roadmap (Dec 2017)

- Since the second meeting the study team has been working on completing a report with the key findings of the study

- This presentation provides an overview of the principal findings of the study

- The presentation by Jeff Hall that follows describes the comparative evaluation of the aerial platforms in more detail

Motivation

- In situ exploration of Venus has been seriously hampered by the severe environment (T =460C and P=90 bars) of the Venus surface.

- Contemporary concepts for lander missions to Venus have more sophisticated instruments but last no longer than Soviet era Venera landers

- There are two plausible pathways to long duration in situ mission on Venus
  - Aerial Platforms operating in the temperate regions of the upper atmosphere
  - Surface Platforms utilizing high temperature electronics

- NASA's Planetary Science Division is currently studying both pathways for Venus exploration and is including both concepts as U.S. provided contribution to a joint mission with Russia (Venera D)

Types of Aerial Platform Considered *

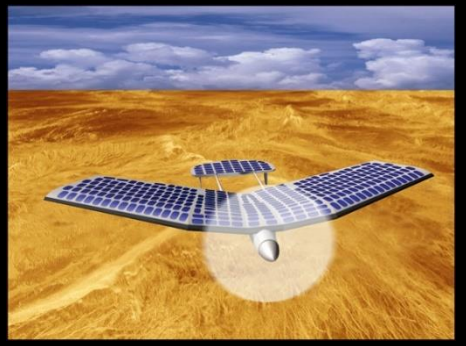
Superpressure Balloon (JPL Venus prototype)

Balloons/Aerobots

Mechanical Compression Balloon (Thin Red Line Aerospace)

Pumped Helium Balloon (Paul Voss CMET)

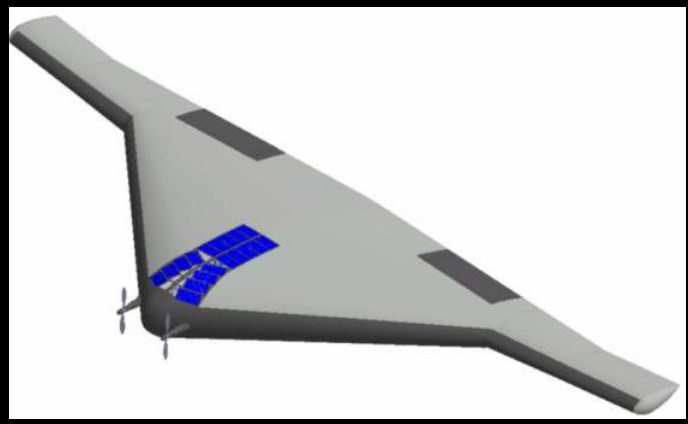
Aircraft and Hybrid



Solar Aircraft (Solar Impulse 2)

Air Ballast Balloon (Google Loon)

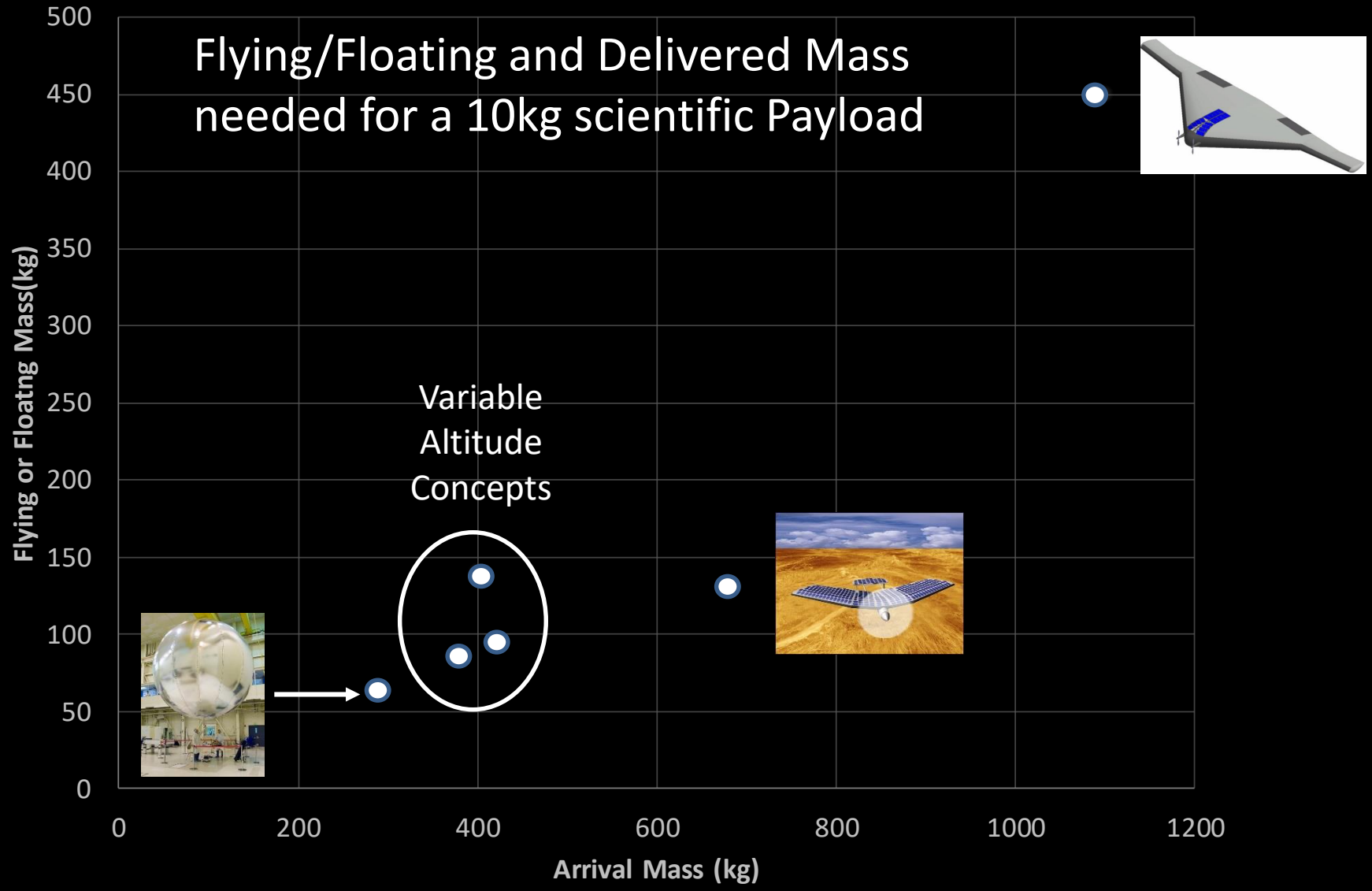
Phase Change Fluid Balloon (JPL)



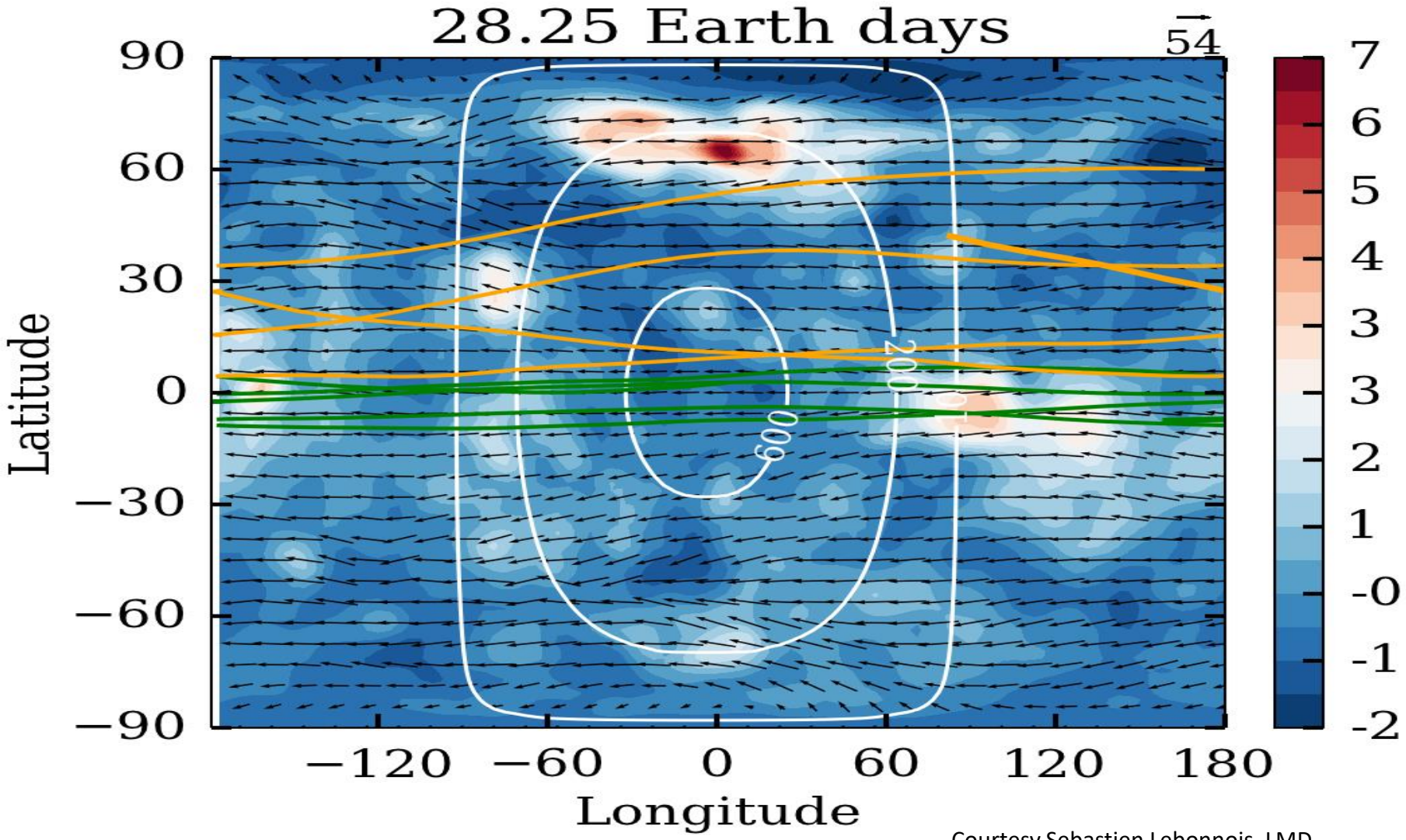
Grumman VAMP)

* Concepts also exist for deep atmospheric exploration but were not considered in this study

Venus Aerial Platform – Trade Study

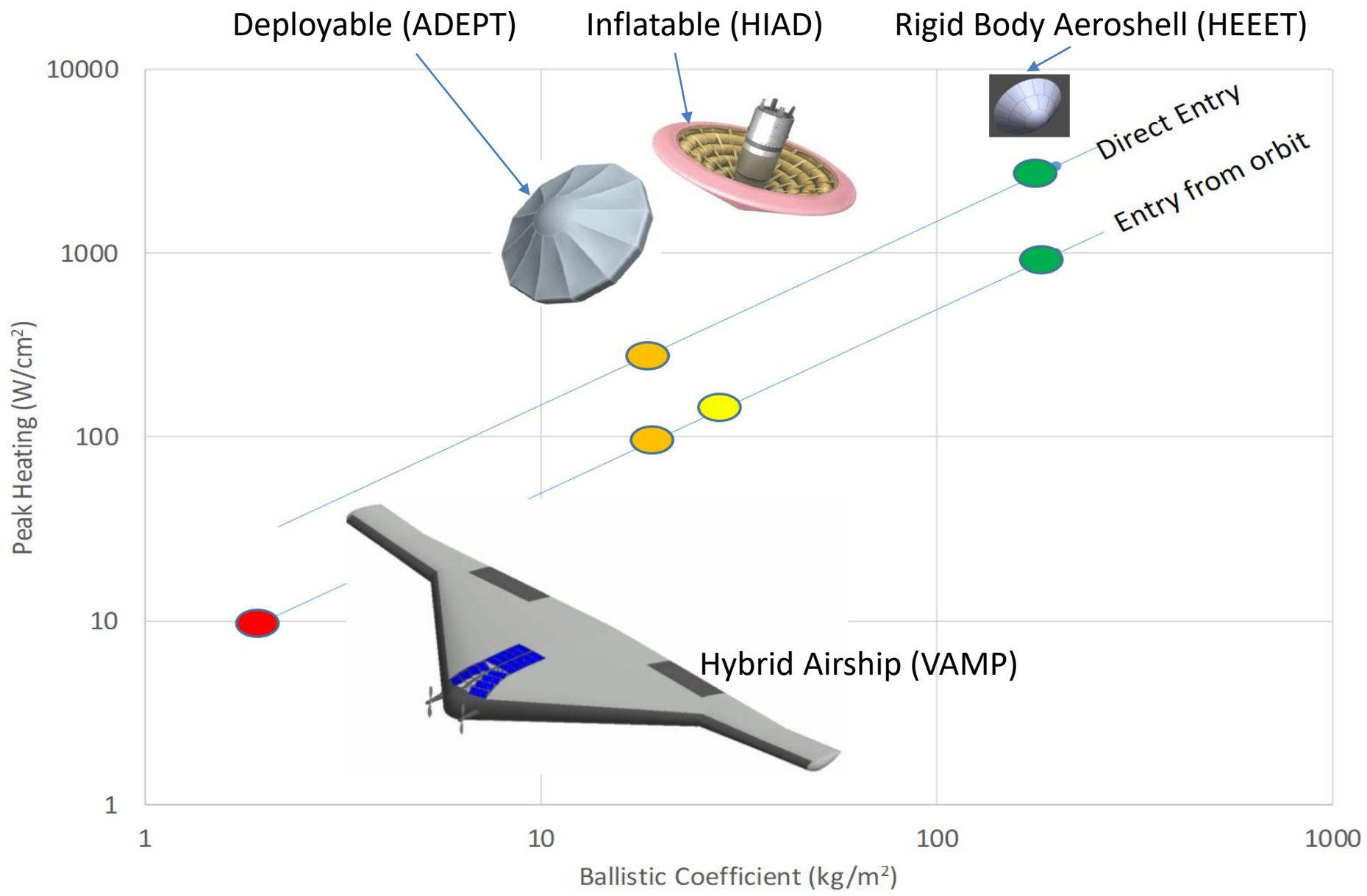


Venus Aerial Platform - Trajectory Models

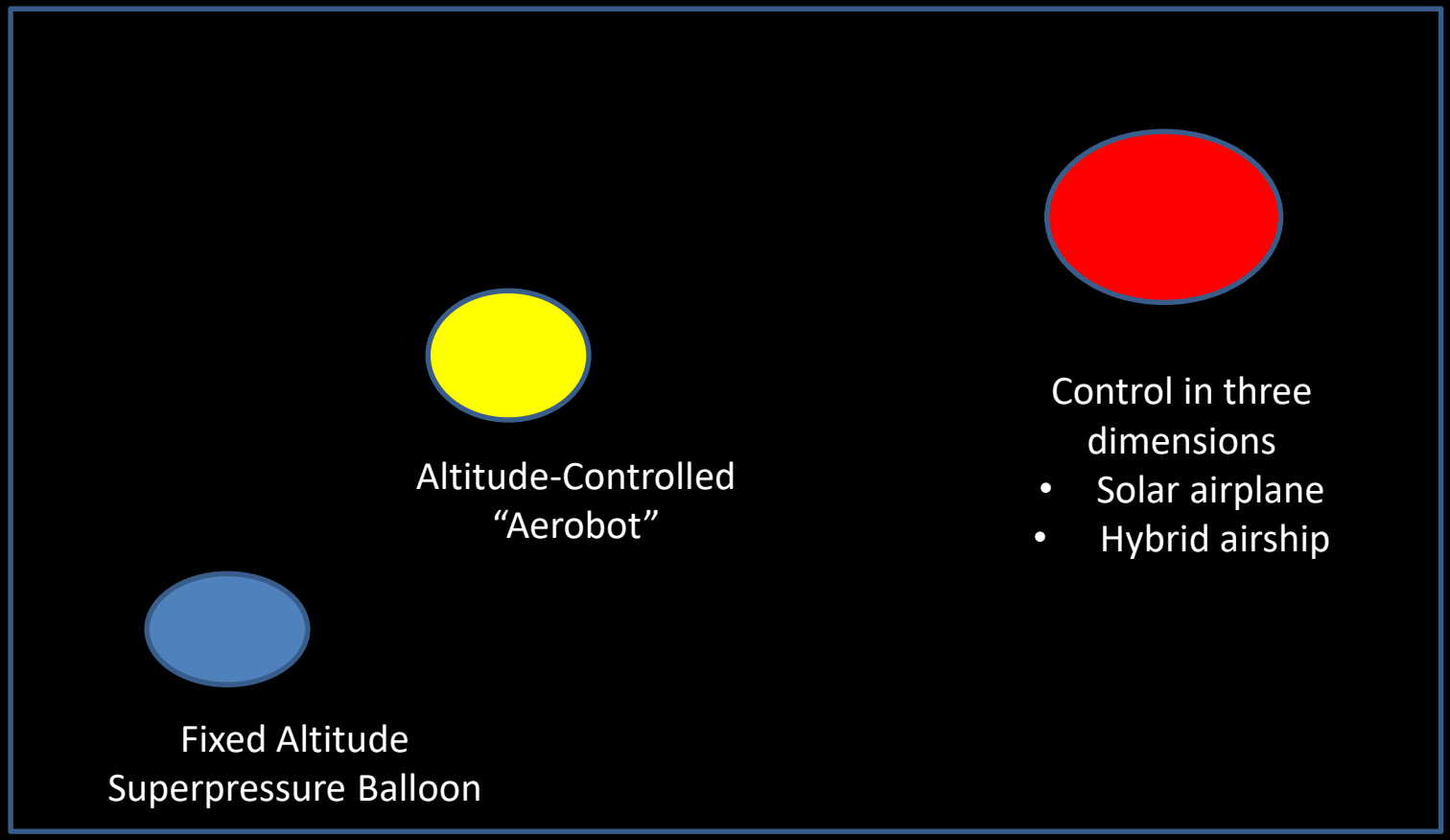


Courtesy Sebastien Lebonnois, LMD

Venus Entry Option Space



Venus Aerial Platforms – Design Sweet Spot



Altitude controlled balloons represent a "sweet spot" in the aerial platform option space.

Venus Aerial Platform Technology Needs

- Altitude Control Systems Development
  - Design and build subscale models of options.
  - Perform laboratory and atmospheric flight tests
  - Compare performance of options
  - Build full scale model of selected option

- Aerobot Science Module (Gondola) Development
  - Demonstrate GN&C and telecommunications systems
  - Integrate science instruments
  - Incorporate miniaturization (SmallSat and CubeSat technologies)
  - Flight test with full scale model

- Modeling and Simulation Tools
  - Venus environment– atmospheric circulation and solar and thermal fluxes
  - Altitude control systems within the Venus environment
  - Power guidance and telecommunications modesl

Summary

- Venus Aerial Platforms (VAPs) could offer a credible pathway to long duration in situ missions at Venus. Missions which explore the temperate zone in the Venus clouds are the place to start

- Focusing on the temperate zone enable us to capitalize on the rich heritage of conventional sensors and electronic systems.

- Although the VAP technology for the simplest type of missions is ready now, a mulit-year investment program focusing on variable altitude capability would enhance the science capability of these platforms

- Among the opportunities for the application of VAP technology are:
  - Joint NASA Russian Venera D Mission Concept– NASA contribution
  - Venus Flagship Mission – currently being studied by NASA
  - Venus Bridge – atmospheric elements
  - Future competitive opportunities – New Frontiers and Discovery